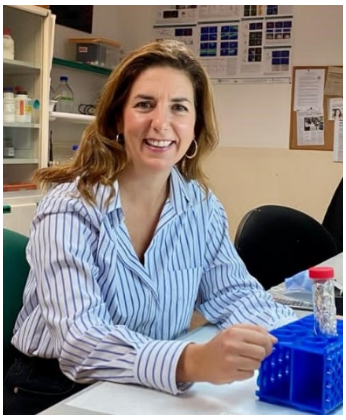
2021 LOUIS-JEANTET SYMPOSIUM

12 October 2021



Guillermina López-Bendito

Instituto de Neurociencias, Alicante, Spain

The thalamus that speaks to the cortex: spontaneous activity in the developing brain

Our research team runs several related projects studying the cellular and molecular mechanisms involved in the development of axonal connections in the brain. In particular, our aim is to uncover the principles underlying thalamocortical axonal wiring, maintenance and ultimately the rewiring of connections, through an integrated and innovative experimental programme. The development of the thalamocortical wiring requires a precise topographical sorting of its connections. Each thalamic nucleus receives specific sensory information from the environment and projects topographically to its corresponding cortical. A second level of organization is achieved within each area, where thalamocortical connections display an intra-areal topographical organization, allowing the generation of accurate spatial representations within each cortical area. Therefore, the level of organization and specificity of the thalamocortical projections is much more complex than other projection systems in the CNS. The central hypothesis of our laboratory is that thalamocortical wiring influences and maintains the functional architecture of the brain. We also believe that rewiring and plasticity events can be triggered by activity-dependent mechanisms in the thalamus. Here in this talk, I will present our recent data on the activity-dependent mechanisms involved in thalamocortical guidance and cortical development. I will also present data on the role of this activity in the thalamus in promoting neuroplastic cortical changes following sensory deprivation. Within these projects we are using several experimental programmes, these include: optical imaging, manipulation of gene expression in vivo, cell and molecular biology, biochemistry, cell culture, sensory deprivation paradigms and electrophysiology.

Biography

Dra. Guillermina López Bendito is a CSIC Investigator and group Leader at the Developmental Neurobiology Unit in the Institute of Neuroscience (IN) of Alicante, Spain. During her PhD, she worked on the role and precise cellular and subcellular localization of neurotransmitter receptors during pre-and postnatal development of the cerebral cortex. As a postdoctoral researcher she joined the laboratory of Dr. Zoltán Molnar at Oxford University (UK) where she trained in axon guidance mechanisms and the development of the thalamocortical connectivity. In 2004, she obtained a prestigious “Ramón y Cajal” semi-independent position at the IN in Alicante in the laboratory of Prof Oscar Marin where she started to develop her own research line on the mechanisms involved in thalamocortical axon circuitry formation. Since 2008, she is group leader at the IN where her team runs several related projects to uncover the principles underlying thalamocortical axonal wiring, maintenance and ultimately the rewiring of connections, through an integrated and innovative experimental programme.

http://lopezbenditolab.com

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Botond Roska

Institute of Molecular and Clinical Ophthalmology Basel, Switzerland

Restoring Vision

Vision is a key sense for humans and dysfunction of the visual system leads to visual handicap or blindness. I will discuss how the understanding of the neuronal circuits of the visual system can lead to therapeutic ideas to treat blindness. I will then introduce new technologies to study and manipulate human visual circuits. Finally, I will discuss the translational steps for optogenetic vision restoration from the idea stage to the first treated patients.

Biography

Botond Roska obtained his M.D. at the Semmelweis Medical School, a Ph.D. in neurobiology from the University of California, Berkeley and studied genetics and virology as a Harvard Society Fellow at Harvard University and the Harvard Medical School. He then led a research group at the Friedrich Miescher Institute in Basel from 2005-2018. In 2010 he became Professor at the Medical Faculty and in 2019 Professor at the Science Faculty of the University of Basel. Since 2018 he is a founding director of the Institute of Molecular and Clinical Ophthalmology Basel (IOB). At IOB he leads a research group focusing on the understanding of vision and its diseases and the development of gene therapies to restore vision. He received several awards including the 2018 Louis-Jeantet Prize for Medicine and the 2020 Körber European Science Prize.

www.iob.ch

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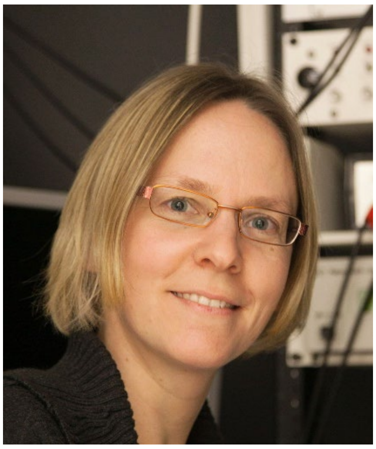

Sonja Hofer

Sainsbury Wellcome Centre, London, UK

Flexible inhibitory control of visually-evoked instinctive behaviour

Producing flexible behavioural responses to changing environmental demands is an essential hallmark of the mammalian brain. Animals can react differently to the same sensory information depending on the behavioural circumstances and their previous experience. However, the neuronal mechanisms of how control of behaviour is achieved are still unclear. My lab is interested in how sensory signals are integrated with other information to interprate sensory input and to generate flexible reactions to environmental challenges. In my talk I will focus on thalamic inhibitory circuits and their role in regulating instinctive, sensory-evoked behaviour. Using a well-characterised model for instinctive behavioural decisions – escape from imminent threat – we identified the ventral lateral geniculate nucleus (vLGN), an inhibitory prethalamic area, as a critical node for control of visually-evoked defensive responses in mice. The vLGN is modulated by previous experience of threatening stimuli and tracks the perceived threat level in the environment. Optogenetic stimulation of vLGN abolishes escape responses, while suppressing its activity lowers the threshold for escape and increases risk-avoidance behaviour. vLGN most strongly affects visual threat responses, likely via modality-specific inhibition of circuits in superior colliculus. Thus, inhibitory vLGN circuits control visually-evoked defensive behaviour depending on an animal's prior experience and its anticipation of danger in the environment.

Biography

Sonja Hofer is a Professor at the Sainsbury Wellcome Centre for Neural Circuits and Behaviour, University College London (UCL). She undertook her PhD at the Max Planck Institute of Neurobiology, Martinsried, Germany, after which she went to UCL as a Postdoctoral Researcher. From 2013 to 2017 she held an Assistant Professorship at the Biozentrum, University Basel, Switzerland. She received several awards including the Wellcome Beit Prize and Kandel Young Neuroscientists Prize. Her research focuses on understanding the neural basis of sensory perception. Her laboratory studies how the brain processes visual information, how visual neural networks are shaped by experience and learning, and how they integrate visual signals with other information in order to interpret the outside world.

https://www.sainsburywellcome.org/web/groups/hofer-lab

2021 LOUIS-JEANTET SYMPOSIUM

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Virginie van Wassenhove

Cognitive Neuroimaging Unit, NeuroSpin, CEA, INSERM, CNRS, Université Paris-Saclay, 91191 Gif/Yvette, France

Making sense of time in the brain

How neural circuits use, code, and represent time remain debated; yet, the status of time in neurosciences is foundational to perception, cognition and neural computations. For instance, temporal coincidence serves multisensory integration: the inference of a unique cause from disparate sources of physical energies (e.g. vibrating molecules and photons) requires coincidence detection or simultaneity. Multisensory integration also provides a first level of representational abstraction in neural circuits. How the brain represents time itself is fundamental to the individuation and ordering of internal representations, to the feeling that time passes, that things exist for a while (duration) or that we can, at will, mentally travel to our (no more existing) past and (our not yet) existing future. An epistemological difficulty stands in the way of understanding time in neurosciences: temporalities emerge from the perspective of the brain (the generator, actuator, and observer of events) not from the external observer (the experimenter). A change of temporal coordinate system in cognitive maps could be accompanied by inter-individual variability, which may stand as a feature and not a bug, of neural circuits. This could dramatically affect our models of perception and cognition. I will provide empirical examples that illustrate these arguments, with a long-term goal to understand how complex brain dynamics can code intelligible representations of time in the human mind.

Biography

Virginie van Wassenhove is a Research Director at NeuroSpin (CEA, INSERM, CNRS, Université Paris-Saclay). Her lab explores temporal cognition from the temporal coincidence of multisensory events to the conscious awareness of ordinality. Her PhD in Neuroscience and Cognitive Science (UMCP 2004) proposed that the integration of auditory and visual speech signals in the human brain relies on predictive coding. While postdoc-ing (UCSF, UCLA, Caltech), she became interested in how the brain codes for, and represents, time. She led Neurospin MEG (2008-17) and was gratefully awarded major grants (ERC, Marie Curie, ANR, FET) to pursue her scientific interests. She serves on the editorial boards of Journal of Cognitive Neuroscience and eLife.

https://brainthemind.com/

2021 LOUIS-JEANTET SYMPOSIUM

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Brice Bathellier

The Hearing Institute, Institut Pasteur, Paris, France

Spatial decorrelation of sound representations throughout the auditory system

Auditory perception relies on the separation of the complex spectrotemporal patterns extracted at the cochlea. Yet, the transformations of auditory information that enable this process remains elusive. To address this, we systematically compared population representations of diverse sounds across a detailed biophysical model of the cochlea and extensive recordings in the inferior colliculus, thalamus and auditory cortex of awake mice. Noise-corrected metrics evidenced a spatial decorrelation of sound representations that started in colliculus, reversed in thalamus and was maximal in the cortex. Spatial decorrelation rendered individual neurons more specific for particular acoustic features (frequency, intensity, temporal modulations) or their combinations, a “sparsification” process, operating on the neuronal dimensions, which actually preserved the continuity of representations. Spatial decorrelation of temporal features was strongest in cortex where time-averaging had little effect on the discriminability of time-varying sounds, a population-scale property that was much weaker subcortically. Based on a bioinspired reinforcement-learning model, we show that decorrelation of temporal features boosts discriminative learning of spectrally overlapping time-varying sounds, which may explain why auditory cortex is specifically required to distinguish such complex sounds behaviourally. A similar decorrelation process is observed in artificial deep neural networks if trained to identify a broad enough set of sounds and sound features. Thus, decorrelation is a key transformation operated by the auditory system for a versatile identification of acoustic cues.

Biography

Brice Bathellier studied physics at the ENS Paris, and soon after moved to neuroscience. Since his PhD at EPFL, he studies information processing and network dynamics in sensory systems combining theoretical modelling, *in vivo* recordings and behaviour. After exploring olfactory coding, he focused on auditory representations in cortex and their role in perception and learning, first as a postdoc with Simon Rumpel at the IMP Vienna, and, since 2013, in his own lab, which he started at the Paris-Saclay Institute for Neuroscience. In 2020, he moved to the Hearing Institute, a new research centre of the Institut Pasteur.

https://www.bathellier-lab.org

2021 LOUIS-JEANTET SYMPOSIUM

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Nathalie Rochefort

University of Edinburgh, UK

Neocortex saves energy by reducing coding precision during food scarcity

Information processing is energetically expensive. In the mammalian brain, it is unclear how information coding and energy usage are regulated during food scarcity. We addressed this in the visual cortex of awake mice using whole-cell patch clamp recordings and two-photon imaging to monitor layer 2/3 neuronal activity and ATP usage. We found that food restriction resulted in energy savings through a decrease in AMPA receptor conductance, reducing synaptic ATP usage by 29%. Neuronal excitability was nonetheless preserved by a compensatory increase in input resistance and a depolarized resting membrane potential. Consequently, neurons spiked at similar rates as controls, but spent less ATP on underlying excitatory currents. This energy-saving strategy had a cost since it amplified the variability of visually-evoked subthreshold responses, leading to a 32% broadening in orientation tuning and impaired fine visual discrimination. These findings reveal novel mechanisms that dynamically regulate energy usage and coding precision in neocortex.

Biography

Nathalie Rochefort is an associate professor at the University of Edinburgh where she started her research group in 2014. As an undergraduate, she studied Biology and Epistemology (ENS, Paris). She then obtained a European PhD in Neuroscience from the University Paris-VI and the Ruhr-Universität-Bochum and did her post-doctoral training at the Technical University in Munich. Her work during her PhD and post-doctoral training has contributed to a new understanding of how neurons acquire their functional properties in the visual cortex. This work also led to the development of a powerful technique, in vivo two-photon calcium imaging. Current projects in her lab investigate how behavioural context modulates neuronal activity in the visual cortex. She has won various honors and grants including the prestigious Bernard Katz Lecture Award, the Schilling Research Award of the German Neuroscience Society, the Sir Henry Dale fellowship (Wellcome Trust and Royal Society), the ERC Consolidator grant and EMBO Young Investigator award.

https://rochefortlab.co.uk/

2021 LOUIS-JEANTET SYMPOSIUM

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Georg Keller

Friedrich Miescher Institute, Basel, Switzerland

The significance of self-generated sensory feedback to cortical function

A defining aspect of our brains interaction with the world is the coupling between movement and the resulting sensory feedback. With experience the brain learns to associate specific movements with their sensory consequences and thus builds an internal model of the world. Based on this we speculate that much of what we perceive is not the result of what our sensory organs transmit to our brains but either the result of what we expect to perceive or the result of a large deviation from these expectations. Our work aims to understand the computational contribution of neocortex to this process. Our research focuses on mouse visual cortex and is guided by the ideas of predictive processing. In visual cortex, visual input is compared to predictions of visual input based on these internal models to compute prediction errors. Experience with self-generated visual feedback establishes a finely tuned circuit in visual cortex capable of computing prediction errors between top-down predictions and bottom-up visual input. Our results describe the cortical microcircuit that implements this computation, as well as contributing to our understanding of the molecular markers of the neurons with defined computational roles. Understanding and manipulating this circuit will be instrumental in advancing our understanding of perceptional disturbances, such as those observed in schizophrenia.

Biography

Georg Keller is a research group leader at the Friedrich Miescher Institute for Biomedical Research (FMI) in Basel. He studied theoretical Physics at the ETH Zurich before venturing into neuroscience where he investigated how songbirds learn to sing by listening to their own song in his PhD. His postdoctoral research at the Max Planck Institute of Neurobiology in Munich, pursued the same question of how self-generated sensory feedback is distinguished from external sensory input in the mouse visual system. He started his own research group at the FMI in 2012, where his lab investigates the cortical computations that underlie perception.

https://www.fmi.ch/research-groups/groupleader.html?group=131

2021 LOUIS-JEANTET SYMPOSIUM

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Flavio Donato

Biozentrum, Basel, Switzerland

Minute-scale waves of activity in the medial entorhinal cortex

The medial entorhinal cortex (MEC) creates and internal representation of space through multiple cell types whose activity is tuned to an animal's location (grid, border, and object-vector cells) or its movement through space (head-direction, speed cells). For at least two of such cell types, the grid and the head-direction cells, spatially-tuned activity patterns might result from computations performed by continuous attractor networks. These attractors are embedded in the recurrently-connected MEC network and, as such, might be expected to be coupled among themselves and to other functional cell types that exhibit correlated responses across different stimuli and brain states. How the structure of the MEC network, with its multiple co-existing attractors, constrains the spatiotemporal organization of neuronal activity and its population dynamics remains an open question. Here, we show that, during stereotyped locomotion and in the absence of sensory inputs tuned to navigation or external goals driving the animal's behaviour, neuronal activity in superficial layers of the MEC (MEC-L2) has the potential to self-organize into repeating sequences of neuronal activation. Such sequences, to which the large majority of the MEC-L2 recorded neurons are tuned to, propagate through the network at non-behavioural or plasticity-related timescales (tens of seconds to minutes), and do not exhibit any topography in their anatomical organization. Thus, we reveal the existence of a global, wave-like population dynamics which has the potential to couple distinct and anatomically distant functional cell types, and hence might prevent individual attractors from drifting apart as a consequence of noise accumulated independently upon experience.

Biography

Flavio Donato is an assistant professor of Neurobiology at the Biozentrum of the University of Basel. His research focuses on understanding how the infant brain acquires the ability to represent information about its experiences, how infants use such information to create general knowledge of the world, and how both these processes shape the brain's maturation and affect neural computations carried out during adulthood.

https://www.donatolab.com/

2021 LOUIS-JEANTET SYMPOSIUM

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Josh McDermott

MIT, Cambridge, USA

New Models of Human Hearing via Machine Learning

Humans derive an enormous amount of information about the world from sound. This talk will describe our recent efforts to leverage contemporary machine learning to build neural network models of our auditory abilities and their instantiation in the brain. Such models have enabled a qualitative step forward in our ability to account for real-world auditory behavior and illuminate function within auditory cortex. But they also exhibit substantial discrepancies with human perceptual systems that we are currently trying to understand and eliminate.

Biography

Josh McDermott studies sound and hearing in the Department of Brain and Cognitive Sciences at MIT, where he heads the Laboratory for Computational Audition. His research addresses human and machine audition using tools from engineering, neuroscience, and psychology. McDermott obtained a BA in Brain and Cognitive Science from Harvard, an MPhil in Computational Neuroscience from University College London, a PhD in Brain and Cognitive Science from MIT, and postdoctoral training in psychoacoustics at the University of Minnesota and in computational neuroscience at NYU. He is the recipient of a Marshall Scholarship, a McDonnell Scholar Award, an NSF CAREER Award, and a Troland Research Award.

http://mcdermottlab.mit.edu/

2021 LOUIS-JEANTET SYMPOSIUM

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Massimo Scanziani

University of California, San Francisco, USA

A Primary Visual Cortex for an Ancient Midbrain Structure

Visual responses in the mammalian cerebral cortex are believed to rely on the geniculate input to primary visual cortex (V1). Indeed, V1 lesions dramatically reduce visual responses throughout cortex. Visual information enters cortex also through the superior colliculus (SC) yet the function of this input on visual responses in cortex is less clear. I will present data showing that visual responses in mouse lateral visual cortical areas called POR and LI are independent of V1 and abolished upon silencing SC. Furthermore, I will show that visual information from the SC reaches POR and LI via the pulvinar nucleus of the thalamus. Indeed, selectively eliminating synaptic transmission in SC neurons that project to the pulvinar abolishes visual responses in POR and LI. Thus, POR and LI are primary collicular visual cortices independent of the geniculo-cortical pathway and are capable of motion discrimination.

Biography

Massimo Scanziani studies the structure and function of neural circuits in mouse visual cortex and focuses on how those circuits contribute to the processing sensory information. Scanziani earned his Ph.D. from the Swiss Federal Institute of Technology in Zurich in 1994 and completed a postdoctoral fellowship at the University of California, San Francisco. In 1999 he took a faculty position at the Brain Research Institute of the University of Zurich, Switzerland and in 2002 he joined the faculty of the University of California, San Diego. Since 2008 he is an Investigator of the Howard Hughes Medical Institute and in 2016 he moved his lab to the University of California, San Francisco.

https://cin.ucsf.edu/scanziani-lab